

(19) Japan Patent and Trademark Office (JP)

(12) LAID OPEN [KÔKAI] PATENT GAZETTE (A)

(11) Patent Laid Open Application Publication No.: 2000-313690
(P2000-313690A)

(43) Date Laid Open: November 14, 2000

(51) Int. Cl ⁵	ID		Subject
	Symbol	F I	Code (Ref.)
C30B 15/20		C30B 15/10	4G077
29/06	502	29/06 502A	

Inspection Request: Filed Number of Claims: 12 OL
(Total 10 pages in original)

(21) Application No.: H11-120550

(22) Date Submitted: April 27, 1999

(71) Applicant: 000221122
Toshiba Ceramics Co. Ltd.
5-25 Nishi Shinjuku 7-chome
Shinjuku-ku, Tokyo, Japan

(72) Inventor: Junichi OSANAI
c/o Toshiba Ceramics Co. Ltd.
Hadano Research Center
30 Sôza, Rakuno-shi
Kanagawa-ken, Japan

(74) Agent: 100078765
Hisashi HATANO, Patent Attorney (and 1 other)

F Subjects (Ref.) 4G022, AA02, BA04, CF08, CF08, ED01, EG11

[Translator's note: Addenda at the end of the Japanese document have been incorporated into the translated text.]

(54) Patent Title: Semiconductor single crystal production method and solid semiconductor raw material ingot used therein

(57) [Abstract]

[Purpose] To provide a semiconductor single crystal production method and solid semiconductor raw material ingot used therein that supply the raw semiconductor ingot without contaminating the single crystal production apparatus, thereby improving the single crystallization yield without extending the cycle time required for a single pulling operation.

[Means of Solution] A semiconductor single crystal production method that possesses a process for affixing a solid raw semiconductor ingot M to a holding means S₂ that is provided on the seed crystal S, a process for melting

P.1

Location	Mode	Start	Time	Page	Result	Note
15097669123	NORMAL	6/ 8,16:50	1'31"	6	* O K	

JPTO Kōkai Patent App. Pub. No. 2000-313690

crystal. The single crystal chamber was then closed and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the seed crystal and silicon polycrystal ingot were lowered into contact with the silicon melt remaining in the quartz crucible, completely melting the silicon polycrystal ingot.

[0058] The yield of the resulting dislocation-free silicon single crystal is shown in Table 1. In this comparison example, the gate valve was opened and closed once. After the part of the seed crystal corresponding with the holding means was then melted, a silicon single crystal was pulled by the usual method. The yield of the resulting dislocation-free silicon single crystal is shown in Table 2. In this condition of embodiment, the gate valve was closed and then opened only once.

[0062] Comparison Example 2 (Recharging System)

One silicon single crystal pulling operation was performed according to the usual method, using the pulling apparatus shown in Figure 9. The resulting single crystal was raised into the single crystal chamber and removed after closing the gate valve.

[0063] Next, a 50kg columnar silicon polycrystal ingot was installed using a special holding means in place of the single crystal that had been pulled. The single crystal chamber was then closed and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the silicon polycrystal ingot was lowered into contact with the silicon melt remaining in the quartz crucible, melting the silicon polycrystal ingot. The holding means was then raised into the single crystal chamber and the gate valve was closed to isolate it from the oven chamber, after which, the single crystal chamber was opened and the special holding means was replaced with a silicon seed crystal for single crystal pulling. The single crystal chamber was then closed, and after the internal atmosphere was brought to the same conditions as those of the oven chamber,

substantially the entire raw semiconductor ingot that is affixed to the holding means S_2 and accommodating same inside a vessel 6, and a process for growing a single crystal Ig by bringing the seed crystal S into contact with the raw semiconductor melt in the vessel 6.

[FIGURE]

- Legend -

- 1 Single crystal production apparatus
- 2 Oven component chamber
- 3 Single crystal container
- 4 Heater
- 6 Quartz crucible
- 10 Seed crystal holding means
- M Raw semiconductor ingot (silicon polycrystal ingot)
- S Seed crystal
- S_2 Holding means (disk-shaped catch)

[Scope of the Patent Claim]

[Claim 1] A semiconductor single crystal production method in which a semiconductor single crystal is grown from a seed crystal by bringing said seed crystal into contact with a raw semiconductor melt contained inside a vessel, wherein which semiconductor single crystal production method is characterized by possessing possesses a process for affixing a solid raw semiconductor ingot to a holding means that is provided on the seed crystal, a process for melting substantially the entire raw semiconductor ingot that is affixed to the holding means and accommodating same inside a vessel, and a process for growing a single crystal by bringing the seed crystal into contact with the raw semiconductor melt in the vessel.

[Claim 2] The semiconductor single crystal production method disclosed in Claim 1, which is characterized by possessing a process for having the semiconductor melt already placed inside the vessel, which process precedes the aforementioned process for melting substantially the entire raw semiconductor ingot that is affixed to the holding means.

[Claim 3] The semiconductor single crystal production method disclosed in Claim 2, which is characterized by the aforementioned process for having the

semiconductor melt already placed inside the vessel being a process in which raw semiconductor material is melted inside the vessel at the very start of semiconductor single crystal production.

[Claim 4] The semiconductor single crystal production method disclosed in Claim 2, which is characterized by the aforementioned process for having the semiconductor melt already placed inside the vessel being a process in which raw semiconductor melt from preceding semiconductor single crystal production is left inside the vessel.

[Claim 5] The semiconductor single crystal production method disclosed in any one of Claims 1 through 4, which is characterized by the aforementioned semiconductor single crystal production method being Czochralski's method.

[Claim 6] The semiconductor single crystal production method disclosed in any one of Claims 1 through 5, which is characterized by the solid semiconductor ingot being a silicon polycrystal and the seed crystal being a silicon single crystal.

[Claim 7] A solid raw semiconductor ingot that, in a raw semiconductor material used in the semiconductor single crystal production method in which a semiconductor single crystal is grown from a seed crystal by Czochralski's method by bringing said seed crystal into contact with the raw semiconductor melt in a vessel, is characterized by the raw semiconductor ingot being held by a holding means that is provided on the aforementioned seed crystal.

[Claim 8] The solid raw semiconductor ingot disclosed in Claim 7, which is characterized by the aforementioned holding of the solid raw semiconductor ingot being accomplished by linking a catch provided in said raw semiconductor material to a holding means provided in the seed crystal.

[Claim 9] The solid raw semiconductor ingot disclosed in Claim 8, which is characterized by the aforementioned holding means provided in the seed crystal being a disk-shaped catch, and by the catch provided in the solid raw semiconductor ingot possessing a linkage groove into which the aforementioned seed crystal is fitted and a void into which the aforementioned disk-shaped catch on the seed crystal is fitted.

[Claim 10] The solid raw semiconductor ingot disclosed in Claim 8 or 9, which is characterized by the aforementioned seed crystal and solid raw semiconductor material both being column-shaped.

[Claim 11] The solid raw semiconductor ingot disclosed in Claim 10, which is characterized by the diameter of the aforementioned disk-shaped catch on the seed crystal being 3 to 4 times greater than the diameter of the column-shaped seed crystal.

[Claim 12] The solid raw semiconductor ingot disclosed in any one of Claims 7 through 11, which is characterized by the solid semiconductor ingot being a silicon polycrystal and the seed crystal being a silicon single crystal.

[Detailed Description of the Invention]

[0001]

[Field of Industrial Application] This invention pertains to a semiconductor single crystal production method and the solid raw semiconductor ingot that is used therein, and more specifically pertains to a semiconductor single crystal production method and the solid raw semiconductor ingot that is used therein that provide for an improved raw semiconductor material supply method and improved single crystallization yield.

[0002]

[Prior Art] The semiconductor single crystal production method commonly used to manufacture semiconductor wafers is one in which a raw semiconductor polycrystal material is melted and a semiconductor single crystal is grown from a seed crystal by bringing said seed crystal, which is made from single crystal, into contact with said raw material melt.

[0003] For example, a method for producing silicon single crystal ingots by Czochralski's method (hereinafter, referred to as the CZ method) consists, as shown in Figure 10, of filling a quartz crucible 43, which is situated inside the oven component chamber 42 of a single crystal production apparatus 41, with silicon polycrystal raw material m_0 in the form of irregularly shaped chunks, and after then heating and completely melting the silicon polycrystal m_0 with a heater that is situated around the outside of the quartz crucible 43, dipping a seed crystal S_0 that is mounted on a seed chuck 45 into the

silicon melt and pulling the seed crystal S_0 , while rotating the seed crystal S_0 and the quartz crucible 43, to grow a silicon single crystal Ig_0 .

[0004] Since the raw silicon polycrystal material commonly used is in the form of irregularly shaped chunks, the chunks of silicon polycrystal m_0 that fill the quartz crucible 43 are heaped up, as shown in Figure 10, making it difficult to fill the quartz crucible with a large quantity at one time. In addition, an expensive new quartz crucible 42 must be used each time a single crystal is pulled, increasing the pulling cost.

[0005] Therefore, a so-called raw material replenishing system has been proposed as a measure to reduce costs. In this raw material replenishing system, a gate valve 52 can be used to separate the single crystal production apparatus 51 into the oven component chamber 53 and the single crystal chamber 54 when necessary, so that, with the gate valve open 52, the quartz crucible 55 situated inside the oven component chamber 53 is filled at the beginning of the single crystal pulling operation (Figure 11(a)), the silicon polycrystal chunks m_0 are melted to fill the quartz crucible 55 approximately 80% with silicon melt L_0 (Figure 11(b)), a solid, rod-shaped silicon polycrystal ingot M_0 , which is raw material that is been prepared separately from the silicon melt L_0 , is held by a silicon ingot holding means 56 and lowered into the silicon melt L_0 whereby it is melted and added to it (Figure 11(c)), causing the silicon melt L_0 to nearly entirely fill the quartz crucible 42.

[0006] On the other hand, after the silicon polycrystal ingot M_0 has been melted, the silicon ingot holding means 56 is raised, the gate valve 52 is completely closed, the silicon ingot holding means 56 is replaced with a seed crystal holding means 57 inside the single crystal chamber 54, which has now been isolated by the gate valve 52, and a seed crystal S is mounted in said seed crystal holding means 57 (Figure 11(d)).

[0007] After this, the gate valve 52 is opened and the seed crystal S_0 is brought into contact with the molten silicon melt L_0 in the quartz crucible 55 and a single crystal Ig_0 with the same crystal orientation as the seed crystal S_0 is grown on the bottom of the seed crystal S_0 (Figure 11(e)), whereby the

silicon melt L_0 inside the quartz crucible 55 is nearly depleted (Figure 11(e)).

[0008] With the semiconductor single crystal production method using the aforementioned single crystal production apparatus 51, the quantity of silicon single crystal produced per quartz crucible is increased over that of common CZ production methods, like that shown in Figure 11.

[0009] However, in this production method, the gate valve 52 must be closed at least once while the heater 58, etc. is on during operation of the single crystal production apparatus 51 to separate the oven component chamber 53 from the single crystal chamber 54. At this time the single crystal chamber 54 must be opened and the seed holding means 57 replaced with the silicon ingot apparatus 56, and then the silicon polycrystal ingot M_0 must be mounted on the silicon ingot holding means 56 or the seed crystal S_0 must be mounted on the seed crystal holding means 57, exposing the single crystal chamber 54 to the atmosphere. When the single crystal chamber 54 is reconnected to the oven component chamber 54 after being exposed to the atmosphere, dust drops down from the single crystal chamber 54, which hinders growth of the single crystal Ig_0 and is a major factor in decreased single crystal yields (the percentage of single crystal obtained without any crystal defects). Furthermore, dust, etc. is also dropped from the gate valve chamber 59 due to opening and closing of the gate valve 52.

[0010] A raw material recharging system, as shown in Figure 12, has also been proposed as a cost reducing measure.

[0011] In this recharging system, a gate valve 62 can be used to separate the single crystal production apparatus 61 into the oven component chamber 63 and the single crystal chamber 64 when necessary, so that, with the gate valve open 62, the single crystal Ig_1 is pulled up and removed, leaving molten silicon L_1 in the quartz crucible 65 situated in the oven component chamber 63 (Figure 12(a)), after which, inside the single crystal chamber 64, now isolated by the gate valve 62, the seed crystal holding means 66 is replaced with a silicon ingot holding means 67 (Figure 12(b)), a silicon polycrystal ingot M_1 is mounted on said silicon ingot holding means 67 and lowered into

the silicon melt L_1 , whereby it is melted into the silicon melt L_1 (Figure 12(c)).

[0012] While the quartz crucible 65 is nearly entirely filled with the silicon melt L_1 by melting the silicon polycrystal ingot M_1 , the silicon holding means 67, on which the silicon polycrystal ingot M_1 that it was holding is no longer present, is raised, the gate valve 62 is closed and, inside the single crystal chamber 64, now isolated by the gate valve 62, the silicon ingot holding means 67 is replaced with seed crystal holding means 66 and a seed crystal S_1 is mounted on said seed crystal holding means 66 (Figure 12(d)).

[0013] The gate valve 62 is then opened, the seed crystal S_1 is brought into contact with the molten silicon polycrystal M_1 in the quartz crucible 65, and a single crystal Ig_1 is caused to grow on the seed crystal S_1 (Figure 12(e)).

[0014] However, in this production method, the gate valve 62 must be closed at least twice while the heater 68, etc. is on during operation of the single crystal production apparatus 61 to separate the oven component chamber 63 from the single crystal chamber 64. At this time the single crystal chamber 64 must be opened and the seed holding means 67 replaced with the silicon ingot apparatus 56, or conversely the silicon ingot apparatus 57 replaced with the seed holding means 67, twice exposing the single crystal chamber 64 to the atmosphere.

[0015] Consequently, the oven component chamber 63 is even further contaminated by dust, etc. in this recharging system than the replenishing system, which hinders growth of the single crystal Ig_0 and is a major factor in decreased single crystallization yields.

[0016] Furthermore, since gas must be replaced inside the pulling apparatus in both the replenishing and recharging systems described above, these also have the problem of requiring longer cycle times for a single pulling operation than the normal CZ method.

[0017]

[Problems to be Solved by the Invention] Therefore, there is a demand for a semiconductor single crystal production method and solid semiconductor raw material ingot used therein with which there is no contamination of the single crystal production apparatus when supplying the raw semiconductor material, thereby improving the single crystallization yield without extending the cycle time required for a single pulling operation.

[0018] Taking the circumstances described above into consideration, the purpose of this invention is to provide a semiconductor single crystal production method and solid semiconductor raw material ingot used therein that supply the raw semiconductor ingot without contaminating the single crystal production apparatus, thereby improving the single crystallization yield without extending the cycle time required for a single pulling operation.

[0019]

[Means of Solving the Problems] The gist of the invention of Claim 1 of this application, created to achieve the aforementioned purpose, is a semiconductor single crystal production method in which a semiconductor single crystal is grown from a seed crystal by bringing said seed crystal into contact with a raw semiconductor melt contained inside a vessel, wherein which semiconductor single crystal production method is characterized by possessing possesses a process for affixing a solid raw semiconductor ingot to a holding means that is provided on the seed crystal, a process for melting substantially the entire raw semiconductor ingot that is affixed to the holding means and accommodating same inside a vessel, and a process for growing a single crystal by bringing the seed crystal into contact with the raw semiconductor melt in the vessel.

[0020] The gist of the invention of Claim 2 of this application is the semiconductor single crystal production method disclosed in Claim 1, which is characterized by possessing a process for having the semiconductor melt already placed inside the vessel, which process precedes the aforementioned process for melting substantially the entire raw semiconductor ingot that is affixed to the holding means.

[0021] The gist of the invention of Claim 3 of this application is the semiconductor single crystal production method disclosed in Claim 2, which is characterized by the aforementioned process for having the semiconductor melt already placed inside the vessel being a process in which raw semiconductor material is melted inside the vessel at the very start of semiconductor single crystal production.

[0022] The gist of the invention of Claim 4 of this application is the semiconductor single crystal production method disclosed in Claim 2, which is characterized by the aforementioned process for having the semiconductor melt already placed inside the vessel being a process in which raw semiconductor melt from preceding semiconductor single crystal production is left inside the vessel.

[0023] The gist of the invention of Claim 5 of this application is the semiconductor single crystal production method disclosed in any one of Claims 1 through 4, which is characterized by the aforementioned semiconductor single crystal production method being Czochralski's method.

[0024] The gist of the invention of Claim 6 of this application is the semiconductor single crystal production method disclosed in any one of Claims 1 through 5, which is characterized by the solid semiconductor ingot being a silicon polycrystal and the seed crystal being a silicon single crystal.

[0025] The gist of the invention of Claim 7 of this application is a solid raw semiconductor ingot that, in a raw semiconductor material used in the semiconductor single crystal production method in which a semiconductor single crystal is grown from a seed crystal by Czochralski's method by bringing said seed crystal into contact with the raw semiconductor melt in a vessel, is characterized by the raw semiconductor ingot being held by a holding means that is provided on the aforementioned seed crystal.

[0026] The gist of the invention of Claim 8 of this application is the solid raw semiconductor ingot disclosed in Claim 7, which is characterized by the aforementioned holding of the solid raw semiconductor ingot being accomplished by linking a catch provided in said raw semiconductor material to a holding means provided in the seed crystal.

[0027] The gist of the invention of Claim 9 of this application is the solid raw semiconductor ingot disclosed in Claim 8, which is characterized by the aforementioned holding means provided in the seed crystal being a disk-shaped catch, and by the catch provided in the solid raw semiconductor ingot possessing a linkage groove into which the aforementioned seed crystal is fitted and a void into which the aforementioned disk-shaped catch on the seed crystal is fitted.

[0028] The gist of the invention of Claim 10 of this application is the solid raw semiconductor ingot disclosed in Claim 8 or 9, which is characterized by the aforementioned seed crystal and solid raw semiconductor material both being column-shaped.

[0029] The gist of the invention of Claim 11 of this application is the solid raw semiconductor ingot disclosed in Claim 10, which is characterized by the diameter of the aforementioned disk-shaped catch on the seed crystal being 3 to 4 times greater than the diameter of the column-shaped seed crystal.

[0030] The gist of the invention of Claim 12 of this application is the solid raw semiconductor ingot disclosed in any one of Claims 7 through 11, which is characterized by the solid semiconductor ingot being a silicon polycrystal and the seed crystal being a silicon single crystal.

[0031]

[Conditions of Embodiment of the Invention] A single crystal production apparatus that uses a so-called raw material replenishing system will be described below, based on the attached figures, as one condition of embodiment of the semiconductor single crystal production method associated with this invention.

[0032] As shown in Figure 1, the single crystal production apparatus that uses the semiconductor single crystal production method of this invention, e.g., a CZ method single crystal pulling apparatus 1, comprises an oven component chamber 2 and a single crystal chamber 3, which is situated above and linked to said oven component chamber 2. A vessel, e.g., a quartz crucible 6, which is built into a graphite crucible 5 and heated by a heater 4, is disposed inside the oven component chamber 2, and chunks of raw silicon

polycrystal m are heated and melted inside this quartz crucible 6. The graphite crucible 5 is mounted on a crucible rotation shaft 8, which passes through the oven body 7 and is linked to and driven by a motor (not shown).

[0033] In addition, a cylindrical seed holding means 10 is provided attached to the lower end of a wire 9, which is disposed so that it can be freely raised and lowered to and from the single crystal chamber 3, and a seed crystal S is mounted in this seed crystal holding means 10.

[0034] As shown enlarged in Figure 2 and Figure 3, the seed crystal S that is mounted in the seed crystal holding means 10 is formed of a seed crystal body S_1 , which is shaped into a true column, and a holding means, e.g., a disk-shaped, circular catch S_2 , which is disposed at one end of said seed crystal body S_1 .

[0035] In addition, a solid semiconductor raw material ingot, e.g., a raw silicon polycrystal ingot with a solid, columnar form, is held on this seed crystal S, and a hollow void M_1 , which accommodates the aforementioned circular catch S_2 , a link M_2 , which is connected to said void M_1 and links with the circular catch S_2 , and a link slot M_3 , which is formed in said link M_2 , are all disposed at one end, e.g., the upper end, of the silicon polycrystal ingot M.

[0036] Now, 11 is a link pin that passes through a mounting hole S_3 provided in the seed crystal S, and holds the seed crystal S to the seed crystal holding means 10.

[0037] It is preferable for the diameter d_1 of the aforementioned circular catch S_2 of the seed crystal S is 3 to 4 times the diameter d_2 of the seed crystal body S_1 , and for the thickness t_1 of the circular catch S_2 to be 20mm or greater. It is also preferable for the thickness t_2 of the link M_2 also to be 20mm or greater and for the height h_1 of the void M_1 to be 50mm or greater.

[0038] Consequently, the silicon polycrystal M is held by the seed crystal S by linking the circular catch S_2 into the link M_2 so that it is accommodated in the void M_3 with the seed crystal body S_1 passing through the link slot M_3 , as shown in Figure 4.

[0039] Next, the raw material replenishing system of the semiconductor single crystal production method of this invention will be described, using the single crystal pulling apparatus 1.

[0040] Figure 8 is a process drawing of a replenishment-type semiconductor single crystal production method, wherein the quartz crucible 6, which is situated inside the oven component chamber 2 of the single crystal pulling apparatus 1, is filled with chunks of raw silicon polycrystal m and a seed crystal S is mounted on the seed crystal holding means 10, which is attached to the end of the wire 9 in the single crystal chamber 3. The seed crystal body S_1 of the seed crystal S is then inserted into the link slot M_3 from the side of the link slot M_3 , so that the circular catch S_2 is accommodated in the void M_3 , linking the circular catch S_2 with the link M_2 , whereby the silicon polycrystal ingot M is suspended from and attached to the wire 9 by means of the seed crystal S and the seed crystal holding means 10 (Figure 8(a)).

[0041] Next, the heater 4, which is disposed around the outside of the quartz crucible 6, is turned on to heat and completely melt the chunks of silicon polycrystal m, filling the quartz crucible 6 approximately 80% with the silicon melt L prior to melting the silicon polycrystal ingot M (Figure 8(b)). Furthermore, the silicon polycrystal ingot M, which was prepared separately from the chunks of silicon polycrystal m and is support by the circular catch S_2 of the seed crystal S that was already placed inside the single crystal void 3, is lowered and melted into the silicon melt L (Figure 8(c)). When the silicon polycrystal ingot M is melted, the silicon melt L nearly entirely fills the quartz crucible 6.

[0042] Meanwhile, the silicon polycrystal ingot M is melted, entirely exposing the seed crystal S and placing it in a state in which it can serve the function as the seed crystal for pulling (Figure 8(d)). Now, in the event that the link M_2 of the silicon polycrystal ingot M remains unmelted on top of the circular catch S_2 , the rate of rotation of the seed crystal S can be increased to cause the link M_2 to drop into the silicon melt L by centrifugal force. Additionally, if silicon polycrystal ingot M is essentially entirely

melted, exposing the circular catch S_2 of the seed crystal S, the unmelted portion of the silicon polycrystal ingot M can be left as it is attached to the seed crystal.

[0043] The interior of the single crystal pulling apparatus 1 is then brought to the single crystal pulling conditions, the circular catch S_2 of the seed crystal S is brought into contact with the molten silicon melt L inside the quartz crucible 6, and, once the circular catch S_2 has melted, the single crystal Ig is grown on the seed crystal S (Figure 8(e)).

[0044] Furthermore, when growing and pulling of the single crystal ingot Ig is completed, there will be no re-useable molten silicon L remaining in the quartz crucible 6 (Figure 8(e)).

[0045] By using the seed crystal S as the basic seed crystal and as a holding means to support the silicon polycrystal ingot M according to the semiconductor single crystal production method of this invention described above, the silicon polycrystal ingot M can be melted as replenishment raw material without needing to open the oven 8 or the single crystal chamber 3 to replace the seed crystal holding means 10 with a silicon ingot holding means. Consequently, it becomes possible to supply enough silicon melt L without contaminating the quartz crucible 6, whereby a large capacity silicon single crystal Ig can be pulled at one time with high single crystallization yield.

[0046] It also becomes unnecessary to selectively separate the single crystal pulling apparatus 1 into an oven component chamber 2 and a single crystal chamber 3 by means of a gate valve, so that the molten silicon melt L is not contaminated by dust, etc. dropping from the single crystal chamber 3 as the gate valve is opened and closed, which in turn allows the single crystallization yield to be increased since there is no hindrance to the growth of the single crystal.

[0047] Furthermore, since there is no need to open the oven 7 or the single crystal chamber 3 during the series of processes, except when simultaneously installing the chunks of silicon polycrystal m and the silicon polycrystal ingot M at the beginning of the pulling process, and when removing the single crystal ingot Ig that has been pulled, gas replacement also becomes

unnecessary, so that the cycle time required for a single pulling operation becomes no longer than with the normal CZ method.

[0048] Next, the so-called raw material recharging system, which is another condition of embodiment of the semiconductor single crystal production method of this invention, will be described, using the single crystal pulling apparatus 1 described above.

[0049] Figure 9 is a process drawing of a recharge-type semiconductor single crystal production method, wherein the single crystal Ig being pulled is pulled and molten silicon L is left in the quartz crucible 6 (Figure 9(a)), after which, the gate valve is closed and the single crystal Ig is removed, while a seed crystal S with the same structure as that shown in Figure 8 and used in the condition of embodiment described above is mounted in the seed crystal holding means 10, and the circular catch S_2 of said seed crystal S is linked into the void M_1 in the silicon polycrystal ingot M (Figure 9(b)). The silicon polycrystal ingot M is then lowered and melted into the silicon melt L already in the quartz crucible 6 (Figure 9(c)). When the silicon polycrystal ingot M is melted, the silicon melt L nearly entirely fills the quartz crucible 6.

[0050] Meanwhile, the silicon polycrystal ingot M is melted, entirely exposing the seed crystal S and placing it in a state in which it can serve the function as the seed crystal for pulling (Figure 9(d)). The interior of the single crystal pulling apparatus 1 is then brought to the single crystal pulling conditions, the circular catch S_2 of the seed crystal S is brought into contact with the molten silicon melt L inside the quartz crucible 6, and, once the circular catch S_2 has melted, the single crystal Ig is grown on the seed crystal S (Figure 9(e)).

[0051] By using the seed crystal S as the basic seed crystal and as a holding means to support the silicon polycrystal ingot M according to the semiconductor single crystal production method of this invention described above, it is necessary to open the single crystal chamber 3 only once to replace the seed crystal holding means 10 and the silicon ingot holding means. Consequently, it becomes possible to pull the silicon single crystal Ig with

good single crystallization yield, which contributes to lower the costs of producing semiconductor single crystals.

[0052] Thus, it becomes possible to supply enough silicon melt while decreasing the number of times that the gate valve is opened and closed, which was at least twice in the past recharging method, and decreasing the chances for contamination inside the oven accompanying said opening and closing, making it possible to pull silicon single crystals with high single crystallization yield.

[0053]

[Example Embodiment] Example Embodiment 1 (Replenishment System)

Using the pulling apparatus shown in Figure 8, with the oven chamber 2 and single crystal chamber 3 open to the atmosphere, a 22-inch diameter quartz crucible was filled with 100kg of silicon polycrystal chunks. A seed crystal equipped with the holding means of this invention was then placed in the single crystal chamber 3 in this state and a 20kg columnar silicon polycrystal ingot was suspended on said seed crystal. Then, the oven chamber and single crystal chamber were closed with the gate valve in the open state.

[0054] Next, after melting the silicon polycrystal inside the quartz crucible, the silicon polycrystal held by the seed crystal was lowered, brought into contact with the silicon melt in the quartz crucible and completely melted. The seed crystal was then brought into contact with the silicon melt, melting the part corresponding with the holding means, after which, a silicon single crystal was pulled by the usual method. The yield of the resulting dislocation-free silicon single crystal is shown in Table 1. In this condition of embodiment, there was no opening or closing of the gate valve.

[0055] Comparison Example 1 (Replenishment System)

Using the pulling apparatus shown in Figure 8, with the oven chamber 2 and single crystal chamber 3 open to the atmosphere, a 22-inch diameter quartz crucible was filled with 100kg of silicon polycrystal chunks. A columnar silicon polycrystal ingot was then suspended in the single crystal chamber 3

in this state by means of a special holding means, and the oven chamber and single crystal chamber were closed with the gate valve in the open state.

[0056] Next, after melting the silicon polycrystal inside the quartz crucible, the silicon polycrystal held by the special holding means was lowered, brought into contact with the silicon melt in the quartz crucible and melted.

[0057] The holding means was then raised into the single crystal chamber and the gate valve was closed to isolate it from the oven chamber, after which, the single crystal chamber was opened and the special holding means was replaced with a silicon seed crystal for single crystal pulling. The single crystal chamber was then closed, and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the seed crystal was lowered, and a silicon single crystal was pulled according to the usual method.

[0058] The yield of the resulting dislocation-free silicon single crystal is shown in Table 1. In this comparison example, the gate valve was closed and then opened once.

[0059]

[Table 1]

	Example Embodiment 1	Comparison Example 1
Dislocation-free Single Crystal Yield	1.18	1

Note 1: Ratio where the yield of the dislocation-free single crystal in the Comparison Example 1 is set to 1.

Note 2: These figures reflect the average values obtained by 10 pulling operations for each Example Embodiment 1 and Comparison Example 1

[0060] Example Embodiment 2 (Recharging System)

One silicon single crystal pulling operation was performed according to the usual method, using the pulling apparatus shown in Figure 9. The resulting single crystal was raised into the single crystal chamber and removed after closing the gate valve.

[0061] Next, a seed crystal equipped with the holding means of this invention was installed in place of the single crystal that had been pulled and a 50kg columnar silicon polycrystal ingot was suspended on said seed

crystal. The single crystal chamber was then closed and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the seed crystal and silicon polycrystal ingot were lowered into contact with the silicon melt remaining in the quartz crucible, completely melting the silicon polycrystal ingot.

[0058] The yield of the resulting dislocation-free silicon single crystal is shown in Table 1. In this comparison example, the gate valve was opened and closed once. After the part of the seed crystal corresponding with the holding means was then melted, a silicon single crystal was pulled by the usual method. The yield of the resulting dislocation-free silicon single crystal is shown in Table 2. In this condition of embodiment, the gate valve was closed and then opened only once.

[0062] Comparison Example 2 (Recharging System)

One silicon single crystal pulling operation was performed according to the usual method, using the pulling apparatus shown in Figure 9. The resulting single crystal was raised into the single crystal chamber and removed after closing the gate valve.

[0063] Next, a 50kg columnar silicon polycrystal ingot was installed using a special holding means in place of the single crystal that had been pulled. The single crystal chamber was then closed and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the silicon polycrystal ingot was lowered into contact with the silicon melt remaining in the quartz crucible, melting the silicon polycrystal ingot. The holding means was then raised into the single crystal chamber and the gate valve was closed to isolate it from the oven chamber, after which, the single crystal chamber was opened and the special holding means was replaced with a silicon seed crystal for single crystal pulling. The single crystal chamber was then closed, and after the internal atmosphere was brought to the same conditions as those of the oven chamber, the gate valve was opened, the seed crystal was lowered, and a silicon single crystal was pulled according to the usual method.

[0064] The yield of the resulting dislocation-free silicon single crystal is shown in Table 2. In this example, the gate valve was closed and then opened twice.

[0065]

[Table 2]

	Example Embodiment 2	Comparison Example 2
Dislocation-free Single Crystal Yield	1.05	1

Note 1: Ratio where the yield of the dislocation-free single crystal in the Comparison Example 1 is set to 1.

Note 2: These figures reflect the average values obtained by 10 pulling operations for each Example Embodiment 2 and Comparison Example 2

[0066]

[Effect] By using the seed crystal as both a seed crystal and as a holding means whereby the solid raw semiconductor ingot is suspended, according to the semiconductor single crystal production method of this invention, swapping of said holding means is eliminated, making it possible to prevent contamination of the inside of the single crystal production apparatus and the silicon melt that accompanies the supply of raw material by means of a solid semiconductor ingot, and to provide for improved single crystallization yield.

[0067] In addition, this combined use of the seed crystal makes it possible to supply enough silicon melt to the quartz crucible using solid raw semiconductor ingots as raw replenishment material while entirely eliminating exposure the oven or any part thereof, or at least decreasing the number of times it is exposed, and since it further becomes unnecessary to replace the gas inside the oven, there is no extension of the cycle time required for each pulling.

[0068] Furthermore, since the enough uncontaminated silicon melt can be supplied to the quartz crucible when the raw material replenishment system is used, large capacity silicon single crystals can be pulled with high single crystallization yield.

[0069] Additionally, since uncontaminated silicon melt can be repeatedly supplied to the quartz crucible when the raw material recharging system is used, the number of silicon single crystals that can be pulled from a single

quartz crucible with high single crystallization yield can be increased, allowing for decreased production costs.

[0070] Furthermore, since the solid semiconductor raw material ingot can be suspended by linking a link disposed in said raw semiconductor ingot with a holding means disposed in the seed crystal, it becomes possible to use the seed crystal as both a seed crystal and as the holding means whereby the solid semiconductor raw material ingot is suspended, which eliminates the need to replace the holding means, prevents contamination of the raw semiconductor melt that accompanies the supply of raw material by means of a solid raw semiconductor ingot, and allows for increased single crystallization yields. In addition, it becomes unnecessary to replace the gas inside the oven and there is no extension of the cycle time required per single pulling.

[0071] It is further possible to pull high-crystallization yield semiconductor single crystals when the catch disposed on the seed crystal is shaped like a disk.

[0072] Additionally, when the diameter of the circular catch on the seed crystal is 3 to 4 times larger than the diameter of the columnar seed crystal, it is possible to securely hold the solid semiconductor raw material ingot and to pull high-crystallization yield semiconductor single crystals.

[Brief Explanation of the Figures]

[Figure 1] This is a conceptual drawing of the single crystal production apparatus used in the semiconductor single crystal production method of this invention.

[Figure 2] This is a side-view drawing of the seed crystal that is incorporated into the single crystal production apparatus used in the semiconductor single crystal production method of this invention.

[Figure 3] This is a plan-view drawing of the seed crystal shown in Figure 2.

[Figure 4] This is an explanatory drawing showing the condition of linkage between the semiconductor raw material ingot and the seed crystal that is incorporated into the single crystal production apparatus used in the semiconductor single crystal production method of this invention.

[Figure 5] This is a plan-view drawing of the semiconductor raw material ingot shown in Figure 4.

[Figure 6] This is a side-view drawing of the semiconductor raw material ingot shown in Figure 4.

[Figure 7] This is a sectional drawing of the semiconductor raw material ingot shown in Figure 4.

[Figure 8] This is a process drawing of the production process that is one condition of embodiment of the semiconductor single crystal production method of this invention.

[Figure 9] This is a process drawing of the production process that is another condition of embodiment of the semiconductor single crystal production method of this invention.

[Figure 10] This is a conceptual drawing of the single crystal production apparatus used in a past semiconductor single crystal production method.

[Figure 11] This is a process drawing of the production process of a past semiconductor single crystal production method.

[Figure 12] This is a process drawing of the production process of another past semiconductor single crystal production method.

[Legend]

- | | |
|----------------|--|
| 1 | single crystal production apparatus |
| 2 | oven component chamber |
| 3 | single crystal chamber |
| 4 | heater |
| 5 | graphite crucible |
| 6 | quartz crucible |
| 7 | oven |
| 8 | crucible rotation shaft |
| 9 | wire |
| 10 | seed crystal holding means |
| 11 | link pin |
| M | semiconductor raw material ingot (silicon polycrystal ingot) |
| M ₁ | void |

M₂ link
M₃ link slot
S seed crystal
S₁ seed crystal body
S₂ seed holding means (circular catch)
S₃ mounting hole

[Fig. 3]

[Fig. 5]

[Fig. 6]

[Fig. 7]

[FIGURES]

[Fig. 1]

[Fig. 2]

[Fig. 4]

[FIGURES]

-Legend-

1 single crystal production apparatus
2 oven component chamber
3 single crystal chamber
4 heater
6 quartz crucible
10 seed crystal holding means
M semiconductor raw material ingot (silicon polycrystal ingot)
S seed crystal
S₂ seed holding means (circular catch)

[Fig. 9]

[FIGURES (a)-(e)]

[Fig. 8]

[FIGURES (a)-(f)]

(19) 日本国特許庁 (J P)

(12) 公開特許公報 (A)

(11) 特許出願公開番号
特開2000-313690
(P2000-313690A)

(43) 公開日 平成12年11月14日 (2000. 11. 14)

(51) Int.Cl. ⁷	識別記号	F I	テーマコード (参考)
C 3 0 B 15/02		C 3 0 B 15/02	4 G 0 7 7
29/06	5 0 2	29/06	5 0 2 A

審査請求 未請求 請求項の数12 O L (全 10 頁)

(21) 出願番号 特願平11-120550

(22) 出願日 平成11年4月27日 (1999. 4. 27)

(71) 出願人 000221122

東芝セラミックス株式会社

東京都新宿区西新宿七丁目5番25号

(72) 発明者 小山内 淳一

神奈川県秦野市曾屋30番地 東芝セラミックス株式会社開発研究所内

(74) 代理人 100078765

弁理士 波多野 久 (外1名)

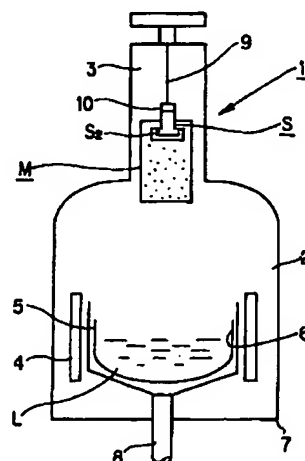
Fターム (参考) 4G077 AA02 BA04 CF06 CF08 ED01
EG11

(54) 【発明の名称】 半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊

(57) 【要約】

【課題】 単結晶製造装置を汚染することなく半導体原料塊の供給が行えて、単結晶化率も向上し、かつ1回の引上げに要するサイクルタイムを長くすることのない半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊を提供する。

【解決手段】 種結晶Sに設けた保持手段S₂に固体の半導体原料塊Mを保持させる工程と、保持手段S₂に保持された半導体原料塊の実質的に全部を溶解して容器6内に收容させる工程と、容器6内の半導体原料融液Lに種結晶Sを接触させて単結晶I gを成長させる半導体単結晶の製造方法。



- 1 単結晶製造装置
- 2 炉部材収納室
- 3 単結晶収納部
- 4 ヒータ
- 6 石英ルツボ
- 10 種結晶保持手段
- M 半導体原料塊 (多結晶シリコン塊)
- S 種結晶
- S₂ 保持手段 (円形係止部)

【特許請求の範囲】

【請求項1】 容器内に収容された半導体原料融液に種結晶を接触させて種結晶から半導体単結晶を成長させる半導体単結晶の製造方法において、種結晶に設けられた保持手段に固体状態の半導体原料塊を保持させる工程と、前記保持手段に保持された前記半導体原料塊を溶解して前記容器内に収容させる工程と、前記容器内の半導体原料融液に前記種結晶を接触させて単結晶を成長させる工程とを有することを特徴とする半導体単結晶の製造方法。

【請求項2】 上記保持手段に保持された半導体原料塊を溶解する工程に先行する前工程として、予め容器内に半導体融液を収容しておく工程を有することを特徴とする請求項1に記載の半導体単結晶の製造方法。

【請求項3】 上記予め容器内に半導体融液を収容しておく工程は、半導体単結晶の製造の初期に容器内に半導体原料を溶解させる工程であることを特徴とする請求項2に記載の半導体単結晶の製造方法。

【請求項4】 上記予め容器内に半導体融液を収容しておく工程は、先行して行われる半導体単結晶の製造において半導体原料融液を残存させておく工程であることを特徴とする請求項2に記載の半導体単結晶の製造方法。

【請求項5】 上記半導体単結晶の製造方法はチョクラルスキー法であることを特徴とする請求項1ないし4のいずれか1項に記載の半導体単結晶の製造方法。

【請求項6】 固体の半導体原料塊は多結晶シリコンであり、種結晶は単結晶シリコンであることを特徴とする請求項1ないし5のいずれか1項に記載の半導体単結晶の製造方法。

【請求項7】 容器内に収容された半導体原料融液に種結晶を接触させて種結晶から半導体単結晶を成長させるチョクラルスキー法による半導体単結晶の製造方法に用いられる半導体原料において、前記種結晶に設けた保持手段により半導体原料塊が保持されたことを特徴とする固体の半導体原料塊。

【請求項8】 上記固体の半導体原料の保持は、この半導体原料に設けられた係止部と種結晶に設けられた保持手段とを係合させることにより行われることを特徴とする請求項7に記載の固体の半導体原料塊。

【請求項9】 上記種結晶に設けられた保持手段は円板形状の係止部であり、固体の半導体原料塊に設けられた係止部は前記種結晶が収納される係合溝部と前記種結晶の円形状の係合部を収納する中空部とを有することを特徴とする請求項8に記載の固体の半導体原料塊。

【請求項10】 上記種結晶および固体の半導体原料は円柱形状であることを特徴とする請求項8または9に記載の固体の半導体原料塊。

【請求項11】 上記種結晶の円形状の係止部の直径は、円柱形状の種結晶の直径の3ないし4倍であること

を特徴とする請求項10に記載の固体の半導体原料塊。

【請求項12】 固体の半導体原料塊は多結晶シリコンであり、種結晶は単結晶シリコンであることを特徴とする請求項7ないし11のいずれか1項に記載の固体の半導体原料塊。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊に係わり、特に半導体原料の供給方法を改善し単結晶化率の向上を図った半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊に関する。

【0002】

【従来の技術】 一般に半導体ウェーハの製造方法は、多結晶半導体原料を溶解し、この原料融液に単結晶よりなる種結晶を接触させ、種結晶から半導体単結晶を成長させる半導体単結晶の製造方法が用いられている。

【0003】 例えば、チョクラルスキー法（以下、CZ法という。）によるインゴット状のシリコン単結晶の製造方法は、図10に示されるように、単結晶製造装置41の炉部材収納室42内に設置された石英ルツボ43に不定形な小塊形状の原料の多結晶シリコンm0を充填し、石英ルツボ43の外周に設けられたヒータ44によって多結晶シリコンm0を完全に加熱溶解した後、シードチャック45に取り付けられた種結晶（シード結晶）S0をシリコン融液に浸し、種結晶S0と石英ルツボ43を逆方向に回転させ種結晶S0を引上げてシリコン単結晶I g0を成長させるものである。

【0004】 一般に使用される原料の多結晶シリコンは不定形な小塊形状であるため、図10に示すように、石英ルツボ43に充填される小塊形状の多結晶シリコンm0は嵩張り、石英ルツボ43に一度に大量に充填することは難しい。また、一回の単結晶引上げ毎に高価な新品の石英ルツボ42を使用せねばならず、引上げコストが上昇する。

【0005】 そこでコスト低減の方策として、図11に示すようないわゆる原料追加チャージ方式が提案されている。この追加チャージ方式は単結晶製造装置51をゲートバルブ52により炉部材収納室53と単結晶収納部54に適宜仕切り可能にし、ゲートバルブ52の開放状態で単結晶引上げ初期に炉部材収納室53に配置された石英ルツボ55に充填し（図11（a））、小塊形状の多結晶シリコンm0を溶解して石英ルツボ55の約80%程度までシリコン融液L0を満たし（図11

（b））、このシリコン融液L0とは別個に用意された原料で固体棒状の多結晶シリコン塊M0をシリコン塊保持手段56により保持して降下させて、シリコン融液L0に接触させて追加溶解させ（図11（c））、シリコン融液L0が石英ルツボ42のほぼ全体に満される。

【0006】 一方、多結晶シリコン塊M0の溶解後、シ

リコン塊保持手段56を上昇させ、完全ゲートバルブ52を閉じ、ゲートバルブ52により仕切られた単結晶収納部54内でシリコン塊保持手段56と種結晶保持手段57とを交換して取り付けし、この種結晶保持手段57に種結晶Sが取り付けられる(図11(d))。

【0007】しかる後、ゲートバルブ52を開放し、種結晶S0を石英ルツボ55中で熔融状態のシリコン融液L0に接触させて、種結晶S0の下部に種結晶S0と同じ結晶方位を有する単結晶I g0を成長させ(図11(e))、石英ルツボ55中にはシリコン融液L0がほとんど残らない状態とする(図11(e))。

【0008】上記の単結晶製造装置51を用いた半導体単結晶の製造方法によれば、図11に示すような通常のCZ法の製造方法よりも石英ルツボ1個当たりのシリコン単結晶の生産量は増大する。

【0009】しかし、この製造方法では、ヒータ58等が付勢された状態で単結晶製造装置51の稼働中に最低でも1回はゲートバルブ52を閉じて、炉部材収納室53と単結晶収納部54とを分離し、かつこの単結晶収納部54を開放してシリコン塊装置56と種結晶保持手段57との取付けの交換を行い、さらにシリコン塊保持手段56への多結晶シリコン塊M0の取り付け、および種結晶保持手段57への種結晶S0の取り付けを行わなければならない、単結晶収納部54は大気に曝される。大気に曝された単結晶収納部54を再度炉部材収納室53と連通させると、単結晶収納部54から塵埃などが落下し、単結晶I g0の成長を阻害し単結晶化率(結晶欠陥が発生せず単結晶が得られる割合)を低減させる大きな要因になっている。さらに、ゲートバルブ52の開閉によるゲートバルブ室59からの塵埃などの落下も生じる。

【0010】また、別のコスト低減の方策として、図12に示すようないわゆる原料のリチャージ方式がある。

【0011】このリチャージ方式は単結晶製造装置61をゲートバルブ62により炉部材収納室63と単結晶収納部64に適宜仕切り可能にし、ゲートバルブ62の開放状態で単結晶I g1を引上げて取り出し、炉部材収納室63に配置された石英ルツボ65に熔融シリコンL1を残存させ(図12(a))、次に、ゲートバルブ62により仕切られた単結晶収納部64内で種結晶保持手段66をシリコン塊保持手段67に交換して取り付け(図12(b))、このシリコン塊保持手段67に多結晶シリコン塊M1を取り付け、降下させてシリコン融液L1に接触させ熔融し、シリコン融液L1にする(図12(c))。

【0012】多結晶シリコン塊M1の熔融によりシリコン融液L1は石英ルツボ65のほぼ全体に満され、一方、保持する多結晶シリコン塊M1が存在しなくなったシリコン保持手段67を上昇させ、ゲートバルブ62を閉じ、ゲートバルブ62により仕切られた単結晶収納部

64内でシリコン塊保持手段67と種結晶保持手段66とを交換して取り付け、この種結晶保持手段66に種結晶S1が取り付けられる(図12(d))。

【0013】しかる後、ゲートバルブ62を開放し、種結晶S1を石英ルツボ65中で熔融状態の多結晶シリコンM1に接触させて、種結晶S1に単結晶I g1を成長させる(図12(e))。

【0014】しかし、この製造方法でも、ヒータ68等が付勢された状態で単結晶製造装置61の稼働中に2回はゲートバルブ62を閉じて、炉部材収納室63と単結晶収納部64とを分離し、かつこの単結晶収納部64を開放して、種結晶保持手段66とシリコン塊保持手段67の交換、および逆にシリコン塊保持手段67と種結晶保持手段66の交換を行う必要があるため、単結晶収納部64は2回も大気に曝される。

【0015】従って、このリチャージ方式は追加チャージ方式に比べてさらに塵埃などの落下により炉部材収納室63を汚損し、単結晶I g0の成長を阻害し単結晶化率を低減させる大きな要因となる虞があった。

【0016】さらに、上述した追加チャージ方式、リチャージ方式とも引上げ装置内のガス置換を必要とするため、1回の引上げに要するサイクルタイムは通常のCZ法よりも長くなる問題点がある。

【0017】

【発明が解決しようとする課題】そこで、原料半導体の供給時、半導体単結晶製造装置内を汚染することがなく、単結晶化率の向上が図れ、かつ1回の引上げに要するサイクルタイムも長くない半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊が要望されていた。

【0018】本発明は上述した事情を考慮してなされたもので、半導体単結晶製造装置を汚染することなく原料半導体供給が行えて、単結晶化率も向上し、かつ1回の引上げに要するサイクルタイムを長くすることのない半導体単結晶の製造方法およびこれに用いられる固体の半導体原料塊を提供することを目的とする。

【0019】

【課題を解決するための手段】上記目的を達成するためになされた本願請求項1の発明は、容器内に収容された半導体原料融液に種結晶を接触させて種結晶から半導体単結晶を成長させる半導体単結晶の製造方法において、種結晶に設けられた保持手段に固体状態の半導体原料塊を保持させる工程と、前記保持手段に保持された前記半導体原料塊を熔融して前記容器内に収容させる工程と、前記容器内の半導体原料融液に前記種結晶を接触させて単結晶を成長させる工程とを有することを特徴とする半導体単結晶の製造方法であることを要旨としている。

【0020】本願請求項2の発明では、上記保持手段に保持された半導体原料塊を熔融する工程に先行する前工程として、予め容器内に半導体融液を収容させておく工

程を有することを特徴とする請求項1に記載の半導体単結晶の製造方法であることを要旨としている。

【0021】本願請求項3の発明では、上記予め容器内に半導体融液を収容しておく工程は、半導体単結晶の製造の初期に容器内に半導体原料を溶解させる工程であることを特徴とする請求項2に記載の半導体単結晶の製造方法であることを要旨としている。

【0022】本願請求項4の発明では、上記予め容器内に半導体融液を収容しておく工程は、先行して行われる半導体単結晶の製造において半導体原料融液を残存させておく工程であることを特徴とする請求項2に記載の半導体単結晶の製造方法であることを要旨としている。

【0023】本願請求項5の発明では、上記半導体単結晶の製造方法はチョクラスキー法であることを特徴とする請求項1ないし4のいずれか1項に記載の半導体単結晶の製造方法であることを要旨としている。

【0024】本願請求項6の発明では、固体の半導体原料塊は多結晶シリコンであり、種結晶は単結晶シリコンであることを特徴とする請求項1ないし5のいずれか1項に記載の半導体単結晶の製造方法。

【0025】本願請求項7の発明では、容器内に収容された半導体原料融液に種結晶を接触させて種結晶から半導体単結晶を成長させるチョクラスキー法による半導体単結晶の製造方法に用いられる半導体原料において、前記種結晶に設けた保持手段により半導体原料塊が保持されたことを特徴とする固体の半導体原料塊であることを要旨としている。

【0026】本願請求項8の発明では、上記固体の半導体原料の保持は、この半導体原料に設けられた係止部と種結晶に設けられた保持手段とを係合させることにより行われることを特徴とする請求項7に記載の固体の半導体原料塊であることを要旨としている。

【0027】本願請求項9の発明では、上記種結晶に設けられた保持手段は円板形状の係止部であり、固体の半導体原料塊に設けた係止部は前記種結晶が収納される係合溝部と前記種結晶の円形状の係合部を収納する中空部とを有することを特徴とする請求項8に記載の固体の半導体原料であることを要旨としている。

【0028】本願請求項10の発明では、上記種結晶および固体の半導体原料は円柱形状であることを特徴とする請求項8または9に記載の固体の半導体原料塊であることを要旨としている。

【0029】本願請求項11の発明では、上記種結晶の円形状の係止部の直径は、円柱形状の種結晶の直径の3ないし4倍であることを特徴とする請求項10に記載の固体の半導体原料塊であることを要旨としている。

【0030】本願請求項12の発明では、固体の半導体原料塊は多結晶シリコンであり、種結晶は単結晶シリコンであることを特徴とする請求項7ないし11のいずれか1項に記載の固体の半導体原料塊であることを要旨と

している。

【0031】

【発明の実施の形態】以下、本発明に係わる半導体単結晶の製造方法の一実施の形態としていわゆる原料追加方式に用いられる単結晶製造装置について添付図面に基づき説明する。

【0032】図1に示すような本発明に係わる半導体単結晶の製造方法に用いられる単結晶製造装置、例えばCZ法による単結晶引上げ装置1は、炉部材収納室2とこの炉部材収納室2の上方に接続して設けられた単結晶収納部3とで形成されている。炉部材収納室2にはヒータ4により加熱され黒鉛ルツボ5に内装された容器例えば石英ルツボ6が設けられており、この石英ルツボ6内で原料の種結晶本体S1が加熱溶解される。黒鉛ルツボ5は炉体7を貫通し、モータ（図示せず）に結合されて回転されるルツボ回転軸8に取り付けられている。

【0033】また、単結晶収納部3には昇降自在に設けられたワイヤ9の下端に取り付けられた円筒形状の種結晶保持手段10が設けられており、この種結晶保持手段10には、種結晶Sが取り付けられている。

【0034】図2および図3に拡大して示すように、種結晶保持手段10に取り付けられた種結晶Sは、中実円柱形状をなす種結晶本体S1とこの種結晶本体S1の一端部に設けられた保持手段例えば円板形状の円形係止部S2とで形成されている。

【0035】また、種結晶Sには固体の半導体原料塊、例えば固体で円柱形状を有する原料の多結晶シリコン塊Mが保持されており、この多結晶シリコン塊Mの一端部例えば上端部には、上記円形係止部S2が収納される中空状の収納部M1と、この収納部M1に接続し円形係止部S2と係合する係止部M2と、この係止部M2に形成された係合溝部M3が設けられている。

【0036】なお、11は種結晶Sに設けられた取付長孔S3を貫通し、種結晶Sを種結晶保持手段10に保持する係合ピンである。

【0037】上記種結晶Sの円形係止部S2の直径d1は、種結晶本体S1の直径d2の3ないし4倍であり、円形係止部S2の厚みt1は20mm以上であることが好ましく、また係止部M2の厚みt2も20mm以上、収納部M1の高さh1は50mm以上であることが好ましい。

【0038】従って、図4に示すように、種結晶Sによる多結晶シリコンMの保持は、種結晶本体S1が係合溝部M3を貫通し、収納部M3に収納された円形係止部S2を係止部M2に係合することによって行われる。

【0039】次に、単結晶引上げ装置1を用いた本発明に係わる半導体単結晶の製造方法の原料追加チャージ方式を説明する。

【0040】図8は追加チャージ方式の半導体単結晶の製造工程図で、単結晶引上げ装置1の炉部材収納室2内

に設置された石英ルツボ6に小塊形状の原料の多結晶シリコンmを充填し、さらに単結晶収納部3のワイヤ9に取り付けられた種結晶保持手段10に種結晶Sを取り付け、しかる後、図4で拡大して示したように種結晶Sの種結晶本体S1を係合溝部M3の側部から係合溝部M3に挿入させながら円形係止部S2を収納部M3に収納させ、円形係止部S2と係止部M2とを係合させることにより、多結晶シリコン塊Mを種結晶Sおよび種結晶保持手段10を介してワイヤ9に懸垂保持させる（図8（a））。

【0041】次に、石英ルツボ6の外周に設けたヒータ4を付勢して多結晶シリコンmを完全に加熱熔融させ、多結晶シリコン塊Mの熔融より先に予め石英ルツボ6の約80%程度までシリコン融液Lを滴させる（図8（b））。

さらに、小塊形状の多結晶シリコンmとは別個に用意され、既に単結晶収納部3に収納され種結晶Sの円形係止部S2により保持されている多結晶シリコン塊Mを降下させてシリコン融液Lに接触させ追加熔融させる（図8（c））。多結晶シリコン塊Mの熔融が完了するとシリコン融液Lは石英ルツボ6のほぼ全体に滴される。

【0042】一方、多結晶シリコン塊Mが熔融されて種結晶Sは完全に露出され、引上げ時の種結晶の機能を果たせる状態になる（図8（d））。なお、多結晶シリコン塊Mの係止部M2が未熔融で円形係止部S2上に残存する場合には、種結晶Sの回転数を上げ遠心力により、係止部M2をシリコン融液L中に落下させればよく、また多結晶シリコン塊Mが実質的に全部溶けて種結晶Sの円形係止部S2が露出されていれば、多結晶シリコン塊Mの一部が未熔融にままだ種結晶Sに取り付けていてもよい。

【0043】しかる後、単結晶引上げ装置1内を単結晶引上げ条件に適合させ、種結晶Sの円形係止部S2を石英ルツボ6中で熔融状態のシリコン融液Lに接触させて、円形係止部S2を融解したのち、種結晶Sに単結晶I gを成長させる（図8（e））。

【0044】さらに単結晶インゴットI gを成長させて引上げを完了させるが、石英ルツボ6内には再使用可能な熔融シリコンLは残存していない（図8（e））。

【0045】上述した本発明に係わる半導体単結晶の製造方法によれば、種結晶Sを、本来の種結晶として用いると共に多結晶シリコン塊Mを保持する保持手段として用いることにより、種結晶保持手段10とシリコン塊保持手段の交換のために、炉体8または単結晶収納部3を開放する必要がなく、多結晶シリコン塊Mを追加原料として熔融できて、石英ルツボ6に汚染のない十分なシリコン融液Lの供給が可能となり、一度に大容量のシリコン単結晶I gを高単結晶化率で引き上げることができる。

【0046】また、単結晶引上げ装置1をゲートバルブ

により炉部材収納室2と単結晶収納部3を適宜仕切るゲートバルブも不要となり、ゲートバルブの開閉に伴い単結晶収納部3から塵埃などが落下して、熔融シリコン融液Lが汚染されることもなくなり、単結晶I gの成長が阻害されることもなく、単結晶化率の高率化も図れる。

【0047】さらに、引上げ工程における最初の小塊形状の多結晶シリコンmと多結晶シリコン塊Mとを同時に装填する時、および引き上げられた単結晶インゴットI gの取り出し時以外に、一連の工程中に炉体7または単結晶収納部3を開放する必要がないため、ガス置換も不必要であり、1回の引上げに要するサイクルタイムも通常のCZ法よりも長くなることがない。

【0048】次に、本発明に係わる半導体単結晶の製造方法の他の実施の形態であるいわゆるリチャージ方式を上述の単結晶引上げ装置1を用いて説明する。

【0049】図9はリチャージ方式の半導体単結晶の製造工程を示すもので、引き上げられた単結晶I gを引上げて、石英ルツボ6に熔融シリコンLを残存させ（図9（a））、次に、ゲートバルブを閉じて単結晶I gを取り出すとともに、上述した実施の形態で用いた図8に示したと同様の構造を有する種結晶Sを種結晶保持具10に取り付け、この種結晶Sの円形係止部S2に多結晶シリコン塊Mの係止部M1を係合させる（図9（b））。しかる後、多結晶シリコン塊Mを降下させて、予め石英ルツボ6に収納されているシリコン融液Lに接触させて熔融し、シリコン融液Lにする（図9（c））。多結晶シリコン塊Mの熔融によりシリコン融液Lは石英ルツボ6のほぼ全体に滴される。

【0050】一方、多結晶シリコン塊Mが熔融した後の種結晶Sは完全に露出され引上げ時の種結晶の機能を果たせる状態になる（図9（d））。しかる後、単結晶引上げ装置1内を単結晶引上げ条件に適合させ、結晶Sの円形係止部S2を石英ルツボ6中で熔融状態のシリコン融液Lに接触させて、種結晶Sに単結晶I gを成長させる（図9（e））。

【0051】本実施形態の半導体単結晶の製造方法によれば、種結晶Sを本来の種結晶として用いると共に多結晶シリコン塊Mを保持する保持手段として用いることにより、種結晶保持手段10とシリコン塊保持手段の交換のために、単結晶収納部3を開放するのは1回で済む。従って、シリコン単結晶I gの高単結晶化率で引き上げることが可能となり、半導体単結晶の製造コスト低減化に寄与する。

【0052】このため、従来のリチャージ法では少なくとも2回であったゲートバルブの開閉回数を低減させ、開閉に伴う炉内への汚染のおそれを低減しつつ十分なシリコン融液の供給が可能となり、シリコン単結晶を高単結晶化率で引き上げることができる。

【0053】

【実施例】実施例1（追加チャージ方式）

図8に記載の引上装置を用い、炉材収納室2および単結晶収納部3が大気解放状態で直径が22インチの石英ルツボに、小形塊状の多結晶シリコンを100kg充填した。ついでこの状態のまま単結晶収納部3に本発明の保持手段を設けた種結晶およびこの種結晶に20kgの円柱形状多結晶シリコン塊を保持させてゲートバルブを解放した状態で炉材収納室および単結晶収納部を閉じた。

【0054】ついで石英ルツボ内の多結晶シリコンを溶解させた後、種結晶に保持させた多結晶シリコンを降下させて石英ルツボ内のシリコン融液と接触させ完全に融解した。続いて種結晶をシリコン融液に接触させ、保持手段に当たる部分を溶解せしめてから通常の方法に従ってシリコン単結晶を引き上げた。得られた無転位シリコン単結晶の収率を表1に示す。本実施形態において、ゲートバルブの開閉は行われていない。

【0055】比較例1（追加チャージ方式）

図8に記載の引上装置を用い、炉材収納室2および単結晶収納部3が大気解放状態で直径が22インチの石英ルツボに、小形塊状の多結晶シリコンを100kg充填した。ついでこの状態のまま単結晶収納部3に専用の保持

手段を介して円柱形状多結晶シリコン塊を保持させてゲートバルブを解放した状態で炉材収納室および単結晶収納部を閉じた。

【0056】ついで石英ルツボ内の多結晶シリコンを溶解させたのち、専用の保持手段に保持させた多結晶シリコンを降下させて石英ルツボ内のシリコン融液と接触させ融解した。

【0057】その後保持手段を単結晶収納部に引き上げ、ゲートバルブを閉じ、炉材収納部と隔離した後に単結晶収納部を開放して専用の保持手段を単結晶引上用のシリコン種結晶に交換した。その後単結晶収納部を閉じ、内部雰囲気を炉材収納部と同一にした後にゲートバルブを開放し、種結晶を降下させて通常の方法に従ってシリコン単結晶を引き上げた。

【0058】得られた無転位シリコン単結晶の収率を表1に示す。本比較例において、ゲートバルブの開閉は1回行われている。

【0059】

【表1】

	実施例1	比較例1
無転位単結晶収率	1.18	1

注1：比較例1における無転位単結晶の収率を1としたときの比

注2：実施例1、比較例1ともに10回の引上の平均値

【0060】実施例2（リチャージ方式）

図9に記載の引上装置を用い、通常の方法に従って、第1回目のシリコン単結晶を引き上げた。引き上げられた単結晶を単結晶収納部に引き上げ、ゲートバルブを閉じて取り出した。

【0061】次に、取り出した単結晶の代りに、本発明の保持手段を設けた種結晶およびこの種結晶に50kgの円柱形状多結晶シリコン塊を保持させて単結晶収納部を閉じ、内部雰囲気を炉材収納部と同一にした後にゲートバルブを開放し、種結晶および多結晶シリコン塊を降下させて石英ルツボに残っているシリコン融液に接触させて多結晶シリコン塊を完全に融解した。その後、種結晶の保持手段に当たる部分を溶解せしめてから通常の方法に従ってシリコン単結晶を引き上げた。リチャージによって得られた無転位シリコン単結晶の収率を表2に示す。本実施例において、ゲートバルブの開閉が行われるのは1回のみであった。

【0062】比較例2（リチャージ方式）

図9に記載の引上装置を用い、通常の方法に従って、第1回目のシリコン単結晶を引き上げた。引き上げられた

単結晶を単結晶収納部に引き上げ、ゲートバルブを閉じて取り出した。

【0063】次に、取り出した単結晶の代りに、専用の保持手段を介して50kgの円柱形状多結晶シリコン塊を保持させて単結晶収納部を閉じ、内部雰囲気を炉材収納部と同一にした後にゲートバルブを開放し、多結晶シリコン塊を降下させて石英ルツボに残っているシリコン融液に接触させて多結晶シリコン塊を融解した。その後、保持手段を単結晶収納部に引き上げ、ゲートバルブを閉じ、炉材収納部と隔離した後に単結晶収納部を開放して専用の保持手段を単結晶引上用のシリコン種結晶に交換した。その後、単結晶収納部を閉じ、内部雰囲気を炉材収納部と同一にした後にゲートバルブを開放し、種結晶を降下させて通常の方法に従ってシリコン単結晶を引き上げた。

【0064】リチャージによって得られた無転位シリコン単結晶の収率を表2に示す。本実施例において、ゲートバルブの開閉は2回行われている。

【0065】

【表2】

	実施例2	比較例2
無転位単結晶収率	1.05	1

注1：比較例2における無転位単結晶の収率を1としたときの比

注2：実施例2、比較例2ともに10回の引上の平均値

【0066】

【発明の効果】本発明に係わる半導体単結晶の製造方法によれば、種結晶を種結晶と固体の半導体原料塊を保持する保持手段として兼用することにより、これら保持手段の交換をなくして、固体の半導体原料塊による原料供給に伴う単結晶製造装置内およびシリコン融液の汚染を防止し、単結晶化率の向上を図ることができる。

【0067】また、種結晶の兼用により、炉体またはその一部の開放をなくし、あるいは開放回数を減少させても、追加原料として固体の半導体原料塊を用いて石英ルツボに十分なシリコン融液の供給が可能となり、さらに炉内ガスの置換も不要となり、1回の引上げに要するサイクルタイムを延長させることもない。

【0068】またさらに、原料の追加チャージ方式に適用すれば、汚染のないシリコン融液を十分に石英ルツボに供給できるので、単結晶化率の高い大容量のシリコン単結晶を引き上げることができる。

【0069】また、原料リチャージ方式に適用すれば、汚染のないシリコン融液を繰り返し石英ルツボに供給できるので、1個の石英ルツボから単結晶化率の高いシリコン単結晶を複数本引き上げることができ、製造コストを低減できる。

【0070】さらに、固体の半導体原料塊の保持は、この半導体原料塊に設けた係止部と種結晶に設けた保持手段とを係合させることにより行うので、種結晶を種結晶と固体の半導体原料塊を保持する保持手段として兼用が可能となり、保持手段の交換をなくして、固体の半導体原料塊による原料供給に伴う半導体原料融液の汚染を防止し、単結晶化率の向上を図ることができる。また、炉内ガスの置換も不要となり、1回の引上げに要するサイクルタイムを長くすることがない。

【0071】さらに、種結晶に設けられた係止部を円板形状にする場合には、単結晶化率の高い半導体単結晶の引上げが可能である。

【0072】また、種結晶の円形状の係止部の直径を、円柱形状の種結晶の直径の3ないし4倍にする場合には、確実に固体の半導体原料塊を保持できると共に、単結晶化率の高い半導体単結晶の引上げが可能である。

【図面の簡単な説明】

【図1】本発明に係わる半導体単結晶の製造方法に用い

られる単結晶製造装置の概念図。

【図2】本発明に係わる半導体単結晶の製造方法に用いられる単結晶製造装置に組み込まれた種結晶の側面図。

【図3】図2に示す種結晶の平面図。

【図4】本発明に係わる半導体単結晶の製造方法に用いられる単結晶製造装置に組み込まれた種結晶と半導体原料塊の係合状態を示す説明図。

【図5】図4に示す半導体原料塊の平面図。

【図6】図4に示す半導体原料塊の平面図。

【図7】図4に示す半導体原料塊の断面図。

【図8】本発明に係わる半導体単結晶の製造方法の一実施形態の製造工程図。

【図9】本発明に係わる半導体単結晶の製造方法の他の実施形態の製造工程図。

【図10】従来の半導体単結晶の製造方法に用いられる単結晶製造装置の概念図。

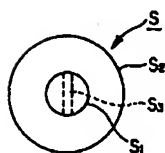
【図11】従来の半導体単結晶の製造方法の製造工程図。

【図12】従来の半導体単結晶の製造方法の他の製造工程図。

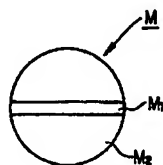
【符号の説明】

- 1 単結晶製造装置
- 2 炉部材収納室
- 3 単結晶収納部
- 4 ヒータ
- 5 黒鉛ルツボ
- 6 石英ルツボ
- 7 炉体
- 8 ルツボ回転軸
- 9 ワイヤ
- 10 種結晶保持手段
- 11 係合ピン
- M 半導体原料塊（多結晶シリコン塊）
- M1 収納部
- M2 係止部
- M3 係合溝部
- S 種結晶
- S1 種結晶本体
- S2 保持手段（円形係止部）
- S3 取付長孔

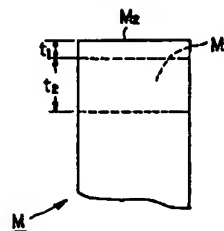
【図3】



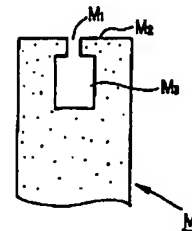
【図5】



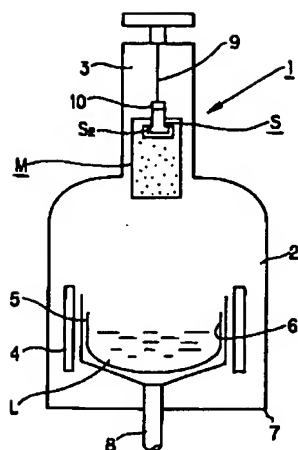
【図6】



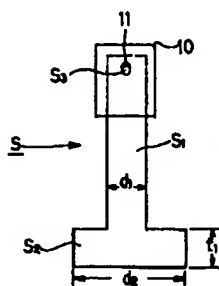
【図7】



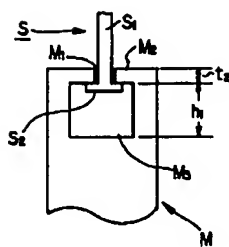
【図1】



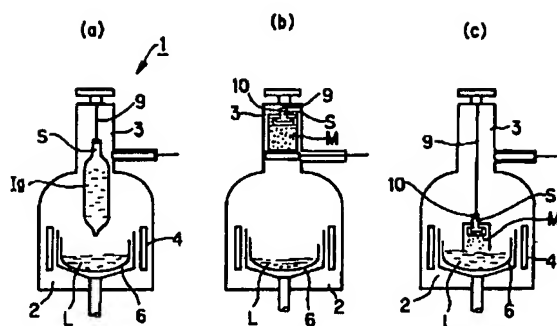
【図2】



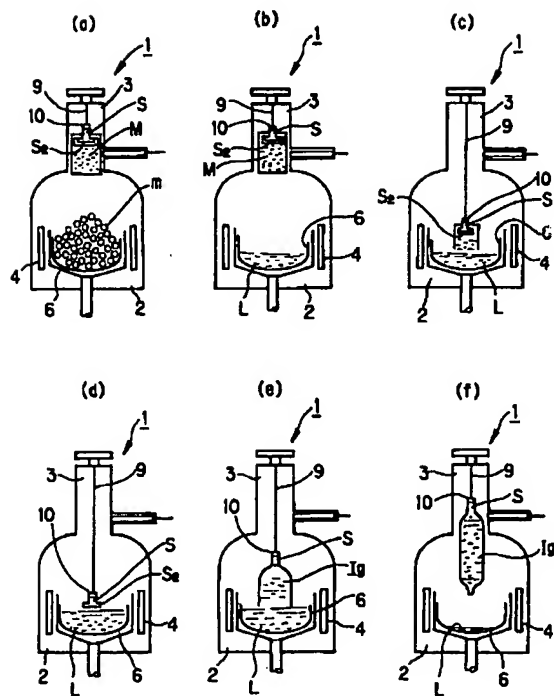
【図4】



【図9】

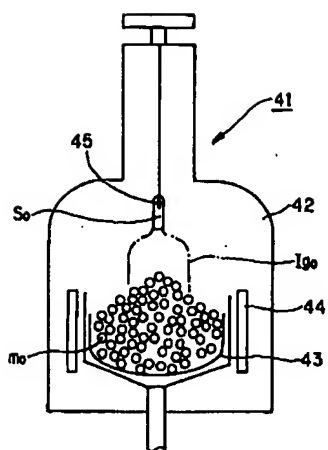


【図8】

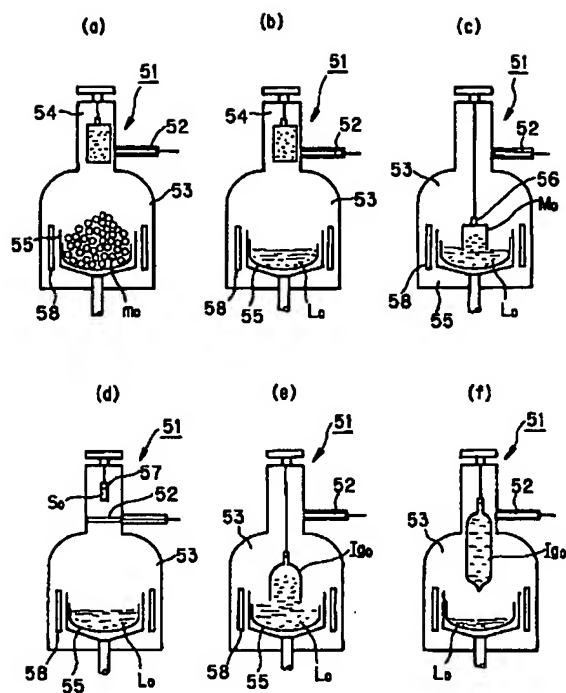


- 1 単結晶製造装置
 2 炉部材収納室
 3 単結晶収納部
 4 ヒータ
 5 石英ルツボ
 6 複結晶保持手段
 M 半導体原料塊(多結晶シリコン塊)
 S 複結晶
 S₂ 保持手段(円形係止部)

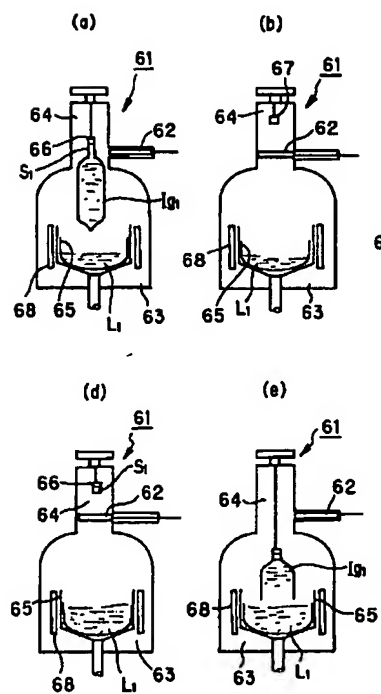
【図 10】



【図 11】



【図 12】



【手続補正書】

【提出日】平成11年6月17日（1999. 6. 17）

【手続補正1】

【補正対象書類名】明細書

【補正対象項目名】0002

【補正方法】変更

【補正内容】

【0002】

【従来の技術】一般に半導体ウェーハの製造方法は、多結晶半導体原料を熔融し、この原料融液に単結晶よりなる種結晶を接触させ、種結晶から半導体単結晶を成長させる半導体単結晶の製造方法が用いられている。

【手続補正2】

【補正対象書類名】明細書

【補正対象項目名】0032

【補正方法】変更

【補正内容】

【0032】図1に示すような本発明に係わる半導体単結晶の製造方法に用いられる単結晶製造装置、例えばCZ法による単結晶引上げ装置1は、炉部材収納室2とこの炉部材収納室2の上方に接続して設けられた単結晶収納部3とで形成されている。炉部材収納室2にはヒータ4により加熱され黒鉛ルツボ5に内装された容器例えば石英ルツボ6が設けられており、この石英ルツボ6内で小塊形状の原料の多結晶シリコンmが加熱熔融される。黒鉛ルツボ5は炉体7を貫通し、モータ（図示せず）に結合されて回転されるルツボ回転軸8に取り付けられている。